ATM NETWORK'S DELAY PARAMETER MEASUREMENT USING SIMULATION METHOD

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Abstract — Network performance in BISDN networks depends primarily on the three lower layers of the B-ISDN protocol : the physical layer, the ATM layer and the AAL layer [1,p267]. Network performance parameters for the ATM layer is the most important. And it includes six QoS parameters which used to measure the performance of the network for a given connection such as: cell loss ratio (CLR), maximum cell transfer delay (MaxCTD), peak-to-peak cell delay variation (p-t-p CDV), cell error ratio (CER), severely errored cell block ratio (SECBR), cell misinsertion rate (CMR) [2,p16]. Furthermore, individual connections within a traffic class use the ATM QoS parameters such as MaxCTD, p-t-p CDV and CLR, or some combination of these depending on the traffic class, to specify maximum end-to-end cell delay, peak-to-peak cell delay variation and cell loss ratio requirements respectively [4,p1]. The network performance parameters for the ATM layer are divided into three groups: those for cell errors, those for cell transfer variations and those for cell transfer timing [1,p273].

The performance parameters for cell transfer timing defined under this paper are the mean cell transfer delay and the cell delay variation. In this paper, we focus on analyzing and examination of CTD based on simulation.

1.ATM testing overview

Asynchronous Transfer Mode (ATM) is a network technology designed to meet the needs of the world's communications services, both today and in the future, and allow integrating a wide range of services having diverse traffic characteristics and quality of service requirements into a single network infrastructure. So the subject of ATM Testing is naturally broad and diverse. Segmentation can be done based on the levels of the ATM protocol model, i.e. from physical transport testing to service protocol testing.

Generally, ATM Testing essentially requires the combination of three key test areas:

- ATM Physical layer testing
- ATM Protocol testing
- ATM Service Protocol testing

1.1.ATM Physical layer testing

ATM can use any digital transmission method available today or under development (ranging from twisted-pair through coax and fiber optic to wireless), at speeds ranging from Kbps to Gbps. Physical transmission test requirements are therefore equally diverse. Regardless of the media, the needs of ATM-based services are no different than those of other services, i.e. transporting digital signals between network equipment with as few errors as possible. This test requirement essentially boils down to ensuring that transmission system meets its specified bit error rates and keeps clock jitter within specified limits.

Additionally, testing must ensure that physical framing procedures function correctly and that any other physical overhead functions, such as error and alarm detection and notification, comply with the appropriate standard. Testers designed for verifying physical transmission in ATM networks therefore are usually based on existing equipment developed to verify digital physical transport for other services, such as PDH, SDH, or SONET TDM networks, or LAN/WAN packet networks.

In addition to testing the physical transport system, the other key Physical layer function is *transmission convergence* of the fixed-length ATM cells into the framing structure of the physical network. Different convergence methods are specified for each defined transport system, but each essentially involves mapping the cell stream (octet-aligned) into the transport frame payload. In most cases the ATM cell stream uses its own framing mechanism, not fixed to the transport framing; this is known as *cell delineation*. Cell delineation testing is the primary function of transmission convergence for most transport systems, it is a basic function of all ATM testers.

1.2.ATM Protocol testing

The ATM protocols define a series of procedures to transport service data across a network of switches. The protocols can be split into these categories:

- Connection management
- Service adaptation
- Cell transport

1.2.1.Connection management

Connection management covers the protocols used to setup and manage virtual connections through the network of ATM switches. Connections can be set up permanently (Permanent Virtual Circuit – PVC), or dynamically set up on demand using signaling protocols (Switched Virtual Circuit – SVC). In both cases, decisions must be made on which route to use through the network to guarantee the quality of service requested by the service user, while maintaining the service quality of the other user connections through the network. For this to take place, the users must specify certain details about their service application, choosing from a range of standard traffic types and classes. If the requested traffic parameters and service quality cannot be provided, the connection request will be rejected.

The key ATM technology that must be tested here is the set of ATM signaling protocols, as shown below:

– UNI (User-Network Interface), the interface between the user's terminal equipment and a network switch [8].
– PNNI (Private Network-Network Interface), the interface between switches inside a private enterprise network [5,p434] [9] [10].
– NNI (Network-Network Interface), the interface between switches inside a public carrier network.
– B-ICI (Broadband Inter Carrier Interface), the interface between different public carrier networks [5,p435].

1.2.2.Service adaptation

ATM cells are short, fixed-length packets, adaptation procedures are required to allow the wide variety of service data structures to be carried across the network. The ATM Adaptation Layer (AAL) defines a series of adaptation techniques to segment service data into cell payloads at the entry point of the ATM network, and to reassemble the received data back to its original format at the exit point from the ATM network. This process is known as Segmentation and Reassembly (SAR).

AAL testing requirements focus on ensuring that SAR functions correctly and that errors correctly detected and handled. Additionally, AAL analysis can be used to measure the proportion of packets successfully reassembled versus those that cannot due to bit errors or cell loss.

1.2.3.Cell transport

Finally, once the connection has been set up and the service data has been segmented into the cell payloads using an AAL, a cell header is added and the service cells are multiplexed into a cell stream (with cells from other services), and sent across the network. On each physical link between switches, the service cells header carries connection identifiers: Virtual Path Identifier (VPI) and Virtual Channel Identifier (VCI). These are used in the switch to reference lookup tables (set up during connection establishment) that define the next physical link (and VPI/VCI for this connection over that link). The cell stream is therefore switched through the network over the predefined route.

In order to allow successful management of ATM cell transport, traffic management procedures are defined in the standards (ITU-T I.371 [6] [7] and ATM Forum UNI/3.1/4.0 [8]). These define procedures for traffic and congestion control, including traffic parameters and descriptors, quality of service, and network performance. Traffic can be classified into four major types, each of which could be routed and managed differently in the network (TM 4.0) [11] [5,p340]. These are:

– CBR (Constant Bit Rate)
– VBR (Variable Bit Rate)
– UBR (Unspecified Bit Rate)
– ABR (Available Bit Rate)

To ensure that service traffic complies with the selected traffic type and parameters, the Usage Parameter Control (UPC) procedure, also known as *policing*, is used. Policing uses a Generic Cell Rate Algorithm (GCRA) which tests each cell as it passes a point in the network (usually the UNI) depend on the specified parameters for the traffic type. Cells that comply are passed on unchanged to the network. Cells that do not comply are either tagged or discarded.

The service agreement between the user and network operator will guarantee quality of service (QoS) performance for cells that comply with the traffic contract. The primary QoS parameters (defined in ITU-T I.356 [12] [13]) are:

- **CLR** (Cell Loss Ratio) [3, p350] [16]

$$CLR = \frac{\text{Lost Cells}}{\text{Transmitted Cells}}$$

The cell loss ratio is the number of cells lost within a period as a proportion of the total number of cells transferred during this period. Cells transferred or lost within severely errored cell blocks are not counted.

- **CTD** (Cell Transfer Delay) [17]
- **CDV** (Cell Delay Variation) [17]

+Mean Cell Transfer Delay (CTD):

The mean cell transfer delay is the arithmetic mean of a specific number of cell transfer delays.

+ Cell Delay Variation (CDV):

There are two distinct types of cell delay variation (CDV): 1-point CDV, 2-point CDV

Other specified QoS parameters include Cell Error Ratio (CER), Cell Misinsertion Rate (CMR), and Severely Errored Cell Block Ratio (SECBR) [3, p546] [17]. These parameters are not affected by congestion in the network.

Cell transport testing focus on verifying that the correct VPI/VCIs are being used, ensuring the correct operation of policing, and measuring the QoS parameters for cell streams through the network.

1.3.ATM Service protocol testing

ATM service protocol testing covers the different specialized requirements for each service using the ATM network, whether directly or through internetworking of ATM with other network technologies such as LAN or

WAN. The particular testing needs of the key services being deployed can be split into:

– Verification of the protocol encapsulation and function mapping of the service data to the ATM network.
– Measurement of the performance of the services across the ATM network.

Additionally, service protocol testing might also require some means of measuring the effect of ATM impairments (such as cell loss and cell delay) on the end user service; one example might be monitoring the effect of cell loss on a compressed digital video signal transported over ATM. Guaranteeing service quality will be assisted greatly by understanding the interaction of protocols through the protocol stack and correlating that with end-to-end measurements across the ATM connection and service endpoints. This capability is called *Service Analysis*.

2.ATM testing simulation program

2.1.Simulation Model

As referred in the previous section, the subject of ATM Testing is broad and diverse. So the ATM testing simulation programs (ATMSim and ATMSwitchSim) described here are aimed at offering an experimental model for ATM testing simulation. In this simulation model, we will carry out the CTD (Cell Transfer Delay) and CDV (Cell Delay Variation) parameters testing [14, p286].

The simulation model is figured below:

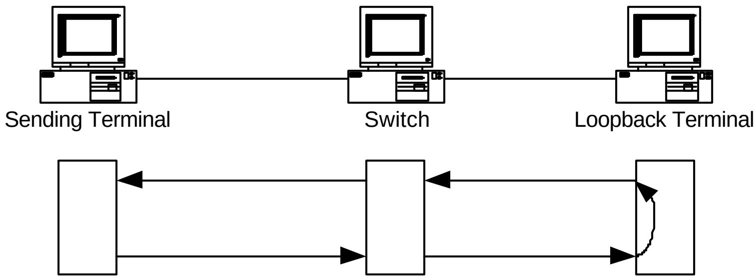

Figure 1: The simulation model

The model include three components:

– Sending Terminal: sending a number of cells to the Switch, and receiving those cells that are looped back, then measuring the cell delays.
– Switch: forwarding the cells from one terminal to other terminal.
– Loopback Terminal: looping back the received cells to the Sending Terminal.

Physically, all three components are ordinary computers, which use Windows 9x operating system and are connected through LAN. These computers become switch or terminal, depending on the configuration of the simulation program that runs on them.

2.2.Program Descriptions

2.2.1.ATM Switch Simulation Program - ATMSwitchSim

This program simulates an ATM Switch that carry out switching ATM cells from one terminal to other. So that this program must have started before the running of ATM Terminal Simulation Program (ATMSim).

Program's interface includes these components:

- Host Name: name of the computer which runs this program.
- IP Address: IP address of the computer which runs this program.
- Port: UDP port number which used for communication by the simulation program.
- Send Cells: number of cells which are sent by the program.
- Receive Cells: number of cells which are received by the program.
- Start Button: to start the program.
- Exit Button: to exit the program.

Program's interface is shown below:

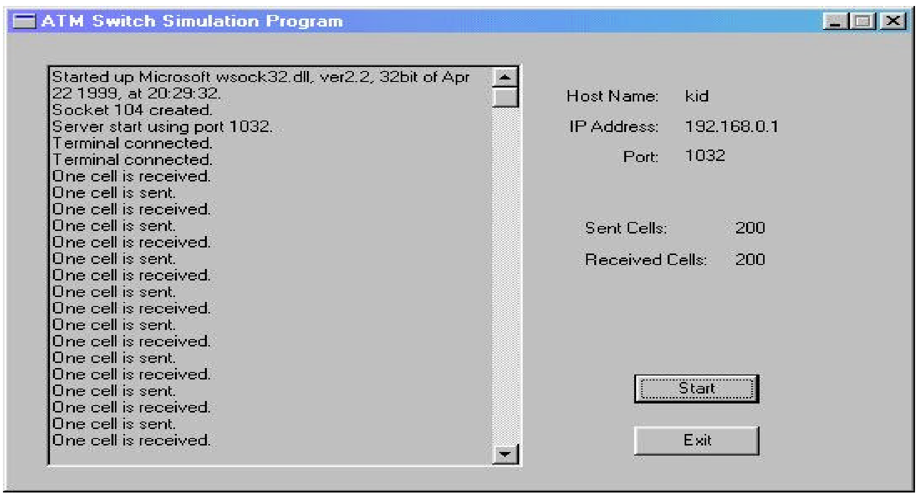

Figure 2: Interface of ATM Switch

When pressing Start Button to start the program, it will show the port number which is used for communication (port 1032 is shown in the image). We will use this port number in the ATMSim program.

2.2.2.ATM Terminal Simulation Program - ATMSim

This program simulates an ATM Terminal. We need two computers to simulate two terminals (as referring in section 2.1): the Sending Terminal will send cells to Loopback Terminal (through the Switch), and Loopback Terminal will loop back those cells to Sending Terminal. These computers become Sending Terminal or Loopback Terminal, depending on the configuration of the simulation program that runs on them.

Program's interface includes these components:

- Local Host Name: name of the computer which runs this program.
- Local IP Address: IP address of the computer which runs this program.
- Server Address: IP address of the computer which plays the role like Switch.
- Port: UDP port number which used for communication by the ATM Switch Simulation Program (ATMSwitchSim).
- Loop back: the option to configure the computer become Loopback Terminal.
- Send data: the option to configure the computer become Sending Terminal. You have to input into the field below the number of cell that you want to send.
- Sent: number of cells which are sent by the program.
- Received: number of cells which are received by the program.
- Connect Button: to connect to the switch simulation program.
- Send Button: to start sending cells.
- Exit Button: to exit the program.

Program's interface is shown below:

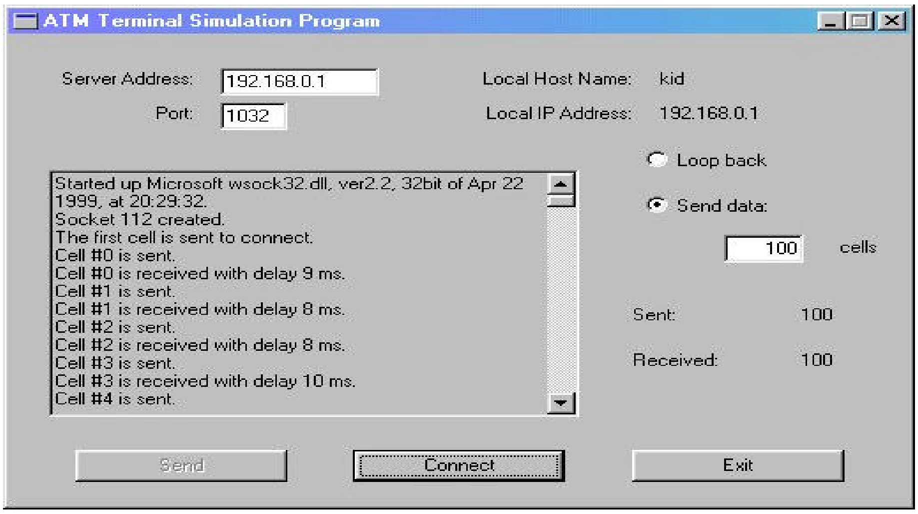

Figure 3: Interface of ATM Terminal

When running the program, we have to enter the IP address as well as the port number of the computer which runs the ATMSwitchSim program (address 192.168.0.1 and port 1032 are shown in the image) into Server Address and Port fields. Then choose Loop-back or Send-data option to configure the program. After that, press Connect Button to connect to Switch. When connecting successfully, press Send Button to transmit/receive data.

If you want to see the CTD diagram after the program finished, choose Yes when the dialog box appears. The CTD diagram is shown below:

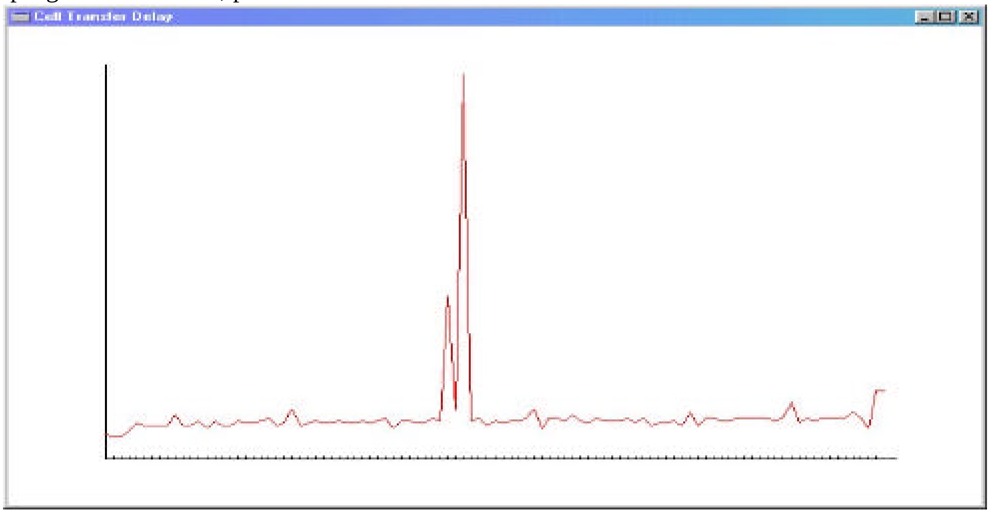

Figure 4: The CTD diagram

3.Conclusions

In this paper we show six QoS parameters which used to measure the performance of the network for a given connection in ATM network and simulate ATM network's delay parameter measurement using visual C++ software [15] in order to solve CTD (Cell Transfer Delay) by simulation method on PC. Additionally, we can simulate a various kind of traffic parameters in order to solve many problems such as cell loss, cell transfer delay, etc. using YATS tool that we wrote in paper [16].

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TRAN CONG HUNG was born in VietNam in 1961

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Sang-Sig Nam was born in 1958 and received the B.S., M.S., and Ph.D. degrees in electronic engineering from Dankook University, Seoul, Korea, in 1981, 1983, and 1999 respectively. He is a Project Leader and Principal Member of the engineering staff at ETRI, which he joined in 1985. He has been engaged in the research and development of digital switching systems such as TDX-1A, 1B, TDX-10 , TDX-10 ISDN, and HANbit ACE ATM & MPLS switching systems. He is a member of the KITE, KICS and KEES of Korea.